The Assessment of Students' Cognitive Conflict by Using Student's Cognitive Map in Solving Mathematics Problem

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Abstract. Knowing students' cognitive conflict when solving mathematical problems is important. We can explore some misconceptions and mistakes made by the students in constructing mathematical concepts. The aim of this study is to assess students' cognitive conflict by using the students' cognitive map. This is a qualitative study that conducted on one 6th grader student of SD Wahid Hasyim Malang. Based on our exploration by using students' cognitive map, it was found that the cognitive conflict occured as a result of conflict between the students' concept with facts/result of the concept.

Keywords : cognitive conflict, cognitive map

Talking about cognitive conflict, is not aimed to a violence or something like that, but rather on about how the occurence of opposing of hope, imbalance, dissonance and disagreement. It has been a lot of research about cognitive conflict, but based on our search results, none of them defines cognitive conflict specifically. According to Piaget's theory, cognitive conflict is identical to an imbalance in assimilation–accommodation process of knowledge. Students' difficulties in assimilating a new knowledge into the existing cognitive schemas can create the imbalance or disequilibrium and indicated as the conflict (Shahbari & Peled, 2014). Kwon (1989) defined cognitive conflict as a conflict between cognitive structure and environment, or a conflict between conceptions in cognitive structure. Lee & Kwon (2001) stated that cognitive conflict is a perceptual state in which a student has a different opinion between what is in the their cognitive structure to the environment or the information they obtained, or between different components such as concepts, beliefs, substructure, etc. The same opinions were also expressed by Lee & Yii (2012) that the cognitive conflict is a condition in which there are different components in someone's cognitive structure and the environment (external information). In this research, we define the cognitive conflict as an awareness about contradiction condition that indicate the occurrence of an imbalance in students' cognitive structure in construction process of mathematical knowledge or concept that created when newly acquired knowledge contradicts to students' prior knowledge.

Some previous studies tried to applied the cognitive conflict in learning instruction. Based on these studies, we know that the researchers had different point of view about the effect of cognitive conflict application in learning. Lee & Kwon (2001), Baser (2006), Akpinar, *et al*. (2009), Shahbari & Peled (2014) and Madu & Orji (2015) states that cognitive conflict-based learning is a good strategy to improve the understanding of students and may encourage the conceptual change. The effect of applying cognitive conflict in learning to facilitate the conceptual change was also discussed by Baser (2006). On his research, he found that students' understanding of heat and temperature concept was improved while the cognitive conflict based physics instruction was applied more than traditional physics instruction. On the same subject, Madu & Orji found that the level of understanding of heat and temperature was significantly dependent to the treatment. They recommended that cognitive conflict instruction should be

adopted by science teachers, educators, and authors and publishers of science books. Akpinar, Erol & Aydogdu (2009) found that the cognitive conflict based activities attracted the teachers' attention and helped them get motivated towards the lesson. While Shahbari & Peled (2014) said that conceptual change and better understanding of the changing reference in fraction calculations was happened to the group of students who teached by using the cognitive conflict. On the other hand, Dreyfus, Jungwirth & Eliovitch (1990), Elizabeth & Galloway (1996), Dekkers & Thijs (1998) argued that even though students' ideas can be confronted with contradictory information through instruction, students frequently do not recognize conflict and sometimes the contardictory information can afect students negatively. So, according to them, the cognitive conflict strategies do not consistently lead to conceptual change.

These different point of views about the impact of the cognitive conflict instruction indicated that the imbalance as the effect of the cognitive conflict not only could bring positive affect but also affected students negatively. Cognitive conflict has constructive, destructive or meaningless potentials (Lee & Kwon, 2001). The destructive or negative effect of cognitive conflict may be the emergence of a negative disposition such as fear, anxiety, and even excessive frustration. Therefore, we think it is necessary to know the cognitive conflict that happened in students' cognitive structure. The reason is that the earlier cognitive conflict studies just discussing about the effectiveness of cognitive conflict in order to bring up the conceptual change. So, the question is how to measure students' cognitive conflicts.

Many researchers has introduced their ways to measure students' cognitive conflict. Lee & Kwon (2001) present The Survey Cards to measure students' level of cognitive conflict. These cards are consist of Four cards, they are recognition of anomaly card, interest card, anxiety card, and reappraisal of cognitive conflict situation card. Lee, *et.al* (2003) used The Cognitive Conflict Level Test to measure cognitive conflict that happened to their subjects. On 2008, Zaskis & Chernoff used the bridging examples to expose their subject's cognitive conflict. They use the counter example as the bridging examples in doing their research. The other way to invoke students' cognitive conflict was introduced by Campitelli & Gerrans on 2014, and known as The Cognitive Reflection Test. There is also Lee & Kwon (2001) who made some gestures that shown by the students as a sign of the onset of cognitive conflict. In this study, we used a cognitive map to measure cognitive conflict that happens to students.

Cognitive mapping is defined as the process that consist of a series of psychological changes made by an individual, and the input of this map include the memory, information code about the connection between the events in daily life (Jacobson, 1998). Pena, Sossa & Gutierrez (2008) define the cognitive map as a tool that gives away the entities of the issue of study. Moreover, according to Pena, Sossa & Gutierrez (2008), cognitive maps bring out the causal phenomena as cause-effect relationships between concepts. According to all researchers, events that occur in someone's thinking structure can be described using a cognitive map. The input of this map was a sequence of someone's psychological changes, their changes in thinking structure, including everything related to their previous knowledge and all activities that are done in a process. So, cognitive maps in this research is defined as a direct connected graph, where the vertex on the graph represents the stages performed by the students or students' concept, while the edge represent the connectivity between the stages and students' concepts. So, the purpose of this research is to measure the student's cognitive conflicts by using student's cognitive maps.

METHODS

Research Framework

This is the qualitative descriptive research that describe how cognitive conflict occurs while student try to solve the geometry problem. This conflict will be investigated by using student's cognitive map while solving rectangle problem. Interview method that used to explore students' cognitive conflict in this research was a think aloud method. The interview process is based on student's worksheet and student's cognitive map while solving the given problem. We conducted 2 kinds of interview to our subject in this research, namely preliminary interview and advance interview. The first kind of interview was to ensure that we can use her spider's web as her cognitive map. Then the last kind of interview was conducted to investigate subject's cognitive conflict. As long as the interview process, we noticed and noted all gesture that disclosed by the subject, which shows the characteristics of the occurence of the cognitive conflict either the body movement that demonstrated by the subject or unusual paraphrases that spoken by the subject. These cues are used by researchers to explore the conflict that occur in subject cognitive structure. Then the result of these interviews are analyzed and outlined in this paper.

Subject and Research Tools

Responden in the first step of this study were 23 sixth-grade student of SD Wahid Hasyim Malang. These 23 student were asked to solve the given problem. The given problem can be seen in Figure 1.

> Mr. Toni has a rectangular-shaped piece of land measuring $160m \ x \ 120m$. On top of the land will be made 4 pieces cages that the fences are made of wire. If the cage to be made a triangular, then specify the size of each cage to be made and how long is the wire that will be used to make the enclosure?

Figure 1: The Given Problem

Next, we made the spider's web of the given problem, and it was figured in Figure 2

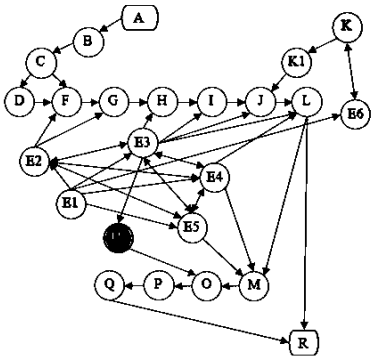

Figure 2: The Spider's Web of The Given Problem

Form the test, we found one student to be our subject. She was Ayu. She was selected based on our research criteria that student who detected the largest incorrect answer while solving the given problem will chosen as the subject, based on the comparison result between the problem's spider's web and subject's spider's web.

Data Collection

All students' activities as long as the test process were recorded. We were made a note along the test process. These records and notes will be compared to students' work. Based on these comparation, we choose Ayu as the subject. Then, Ayu were interviewed by using think aloud method.

Procedure

Firstly, we prepared the problem sheet about the rectangle. After that, we asked the respondent to solve the given problem and taking the field notes as long as the test. Thirdly, we analyzed respondent's answer sheet and field notes. Next, we choosed the suitable subject based on the desirable criteria then identified subject's cognitive conflict. Finally, we analyzed the research findings.

In this research, we had six steps to asses subject's cognitive conflict by using cognitive map. Firstly we created a spider's web based on the elected students' work. Secondly, we identified the error of the subject. Thirdly, we confronted it to the spider's web of the problem structure. Fourthly, we conducted a limited preliminary interview to make a cognitive map. Fiftly, by checking any change of the truth of the answers, we indentified the cognitive conflict. We assumed this as the emergence of the cognitive conflict. Finally, we conducted in-depth interviews about the cognitive conflict that maybe occur in subject's mind, and made the conflict map. (van Someren, M.W., Barnard, Y.F., Sandberg, J.A.C., 1994)

RESULT AND DISCUSSION

Test Result

The first identification about the occurrence of the cognitive conflict to this subject is detected while she is doing the given problem. While solving the given problem, frequently she looks wiggling and playing her pencil and pen, tapping the table by using her pen, scratching her head, and rubbing her nose. This was strengthened by the fact that she identified as the most who made incorrectly answer. While completing the given problem, she shows her seriousness and trying to solve the given problem. On her answer sheet, she wrote that she use $2 \times \ p + l$ as the formula to find the area of the rectangle. Then subject calculate the land area by using that formula, and she found $360m$ as the land area. Then to calculate the area of each cage, she just divide $360m$ to four and obtained the area of the each cage was $90m$. Finally, she wrote that the length of the wire that will be used to make the cage is $30m$. Subject's answer sheet can be seen on Figure 3 below.

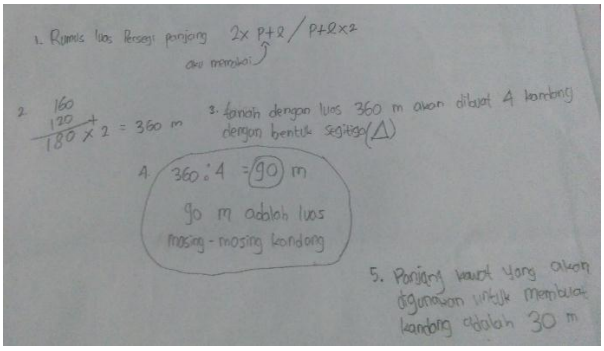

Figure 3: Subject's Answer Sheet

Based on her answer sheet, we assume three things. First, subject had a conception about the rectangle. These assumptions are based on the opinion that the she can drawing the $160m \times 120m$ rectangle. Second, subject had a conception about the triangle. This is based on the consideration that she can describe the triangular area as a form of the cage in the rectangular she made before. The last, subject had a disoriented about the area and the circumference of the rectangle. Then based on these, we made her spider's web as figured in figure 4.

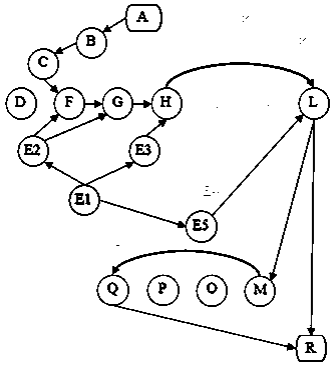

Figure 4: Subject's Spider's Web

We compare this spider's web to the problem spider's web. We found that there are many loosing connectivity in subject's spider's web. We used this spider's web as the basis of interview arranging to make the cognitive map, to explore subject's cognitive conflict by using the cognitive map and to create the conflict map.

Inverview Result

The preliminary interview process started by asking subject about her understating of the given problem. Form this interviewing process, we detected that she know about the sense of the problem. Next, we try to explore her basic supportive concept in solving the problem, and we found that actually subject had enough sopportive concept to solve the given problem. It can be seen from this part of coversation.

Researchers (R) : *What do you think about this problem? what should we do to solve this?*
Subject (S) : *Firstly, I must drawn Mr. Toni's land (drawing a rectangle) It was like the rectangle. So I'll draw the rectangle.*
R : *Hmmm, do you know what the rectangle is?*
S : *Hmmm.... this is rectangle (pointing to her picture)*
R : *Can you explain your idea about rectangle?*
S : *Hmmm... (keep silent for awhile, then continue...) well, this is rectangle (pointing again to her pict). All rectangle has four edges, four vertices, four angles, and the opposite edges are equal.*

From this part of conversation, we claim that subject has a little concept about rectangle.

R : *OK, next?*
S : *This problem said that Mr. Toni want to make a cage on the top of his land. Because there was 4 cages to be made by Mr. Toni, so, it must be like this (drawing two diagonal of the rectangle). We can see here that we find 4 cages, and the shape of the cage were triangle.*
R : *OK, what do you know about the triangle?*
S : *This is triangle. It can be made from the rectangle, like this pict (pointing to her pict), the triangle has three edges, three vertices, and three angles. That was the triangle.*

From this part, we claim that subject has a little concept about triangle.

R : *OK, what next?*
S : *I think it's enough.*
R : *What about the size?*
S : *Oh, (write the size on her picture). This is.*
R : *OK, what do you know to answer this problem?*
S : *Yes of course. It was very simple. Firstly I must count the wide of the rectangle. We know that there were two formula to count it. (write the formula) They are* $2 \times p + l$ *or* $p + l \times 2$. *I choose this one (pointing to* $2 \times p + l$*).*

From this part of the conversation, we can see that subject failed her rectangle concept so we assume that there was a misconception about the wide of the rectangle. It maybe caused by the incompleteness in her rectangle concept.

S : *The size of the land was* $160\ x\ 120$ *meters (write on her paper) so the wide of the land was* $360\ m$.

Subject made a mistake in counting $160 + 120$.

S : *Because there were four same cages in the land so I gotta divide it by 4, and I found the wide of each cage was* $90\ m$.

Subject tried to make a connection between the rectangle and the triangle.

S : *Finally because the triangle has three edges, so I should divide the wide of each cage by 3 to count the circumference of the cage. So the circumference of each cage was* 30

From this small portion of the conversation, we know that subject failed her conception about tringle. She made a wrong connection betwen the wide of the triangle and the circumference of the triangle. So it must be a misconception there.

We conclude some information from the preliminary interview. They are:

1. Subject knew about the rectangle and the triangle
2. Subject faced misconception about the wide and the circumference of the rectangle
3. Subject tried to make a connection between rectangle and triangle
4. Subject tried to make a connection between the wide and the circumference of the triangle
5. Subject faced misconception about the wide of the triangle and the circumference of the triangle
6. Subject untidy in doing his work
7. Subject didn't know about the phytagoras theorem
8. Subject can't applied her knowledge about the rectangle and triangle to solve the given problem

Based on this preliminary interview and the conclusion of the preliminary interview, we made subject's cognitive conflict as figured in Figure 5.

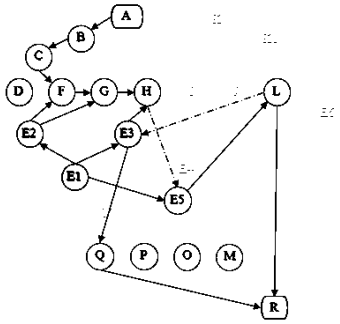

Figure 5: Subject's Cognitive Map

Figure 4 and Figure 5 gives us information that there were so much loosing concept in subject's thinking structure so that this subject made many mistake while doing her given problem. according to these, we conducted in-depth interviews about the cognitive conflict that maybe occurs in subject's mind by using the cognitive map. We kept our focus on subject's mistake and the misconception while doing her work in previous stage to explore her cognitive conflict. The result of this in-depth interview shows that subject faced her cognitive conflict in some part in her concept. They can be seen from these part of conversation along the in-depth interview. R : OK, still remember about this problem? S:yeah,

R : On our previous interview, you drawn a rectangle as the shape of the land, and said that all rectangle had four edges, four vertices, four angles, and the opposite edges were equal. Wasn't it?
S : (Nodding her head)
R : Could you explain your thought about your statement?
S : (Drawing a rectangle and pointing her pict) this is a rectangle. It has four edges (pointing each edges like made a line), four vertices (pointing each vertices), four angles (pointing each angles), and the same size of opposite edges (pointing to the same size of edges). That's all.
R : What bout this part? Is it a rectangle? (pointing to the area that bounded by four edges outside)
S : No, a rectangle just as I told you before.

We identified this case as the potential conflict. Incompleteness in subject concept may be responsible for the occurence of her cognitive conflict. So, we try to continuing to trace her cognitive conflict.

R : OK, can you show me another things that shaped like the rectangle?
S : Hmmm... yes of course, this table.
R : Which part of this table as a rectangle?
S : (pointing each side of the table like made a line)
R : OK, do you know how to count the area and the circumference of this rectangle?
S : Yes, the formula of the rectangle was $2 \times p + l$ *or* $p + l \times 2$. *hmmm yes mmm yes..*

It was clearly form this part of the conversation that the subject began to suspect the existence of any discrepancy to her initial concept. Subject observably began to hesitate her beliefs to her concept. According to Lee & Kwon (2001), student's hesitancy to their beliefs indicate the occurrence of cognitive conflict.

R : OK....
S : Wait a minute mam... (kept in silent for awhile, look like thinking something) (pointing to her pict) this is the length and this is the breadth. Two length and two breadth, so the area of the rectangle is the sum both of them. The circumference... the circumference... hmmm (kept silent for awhile and look like thinking something)
R : Anything else?
S : Mmm... be patient mam... I think something strange here mam. Give me a time to think about this... this is the rectangle (pointing the side of the rectangle and show a motion like making a line along the side of the rectangle)

Subject looked like thinking hardly. Her concept about rectangle was contrary to her idea about the area of the rectangle. Subject's concept about rectangle was not intact. This incompleteness can be the potential conflict in her cognitive structure. Subject's statement "I think something strange here mam" indicate that she was still in her conflict. Lee & Kwon

(2001) stated that student's conscious thought to the peculiarities indicate the occurrence of the conflict.

S : This is look strange mam. I just remember that there was another formula for rectangle, (wrote) $p \times l$. but what did the function? was it to count the circumference? Or the wide.

S : hmmm, I give up mam, I can't find the answer. Aren't they have a relationship? Hmm I don't think so.

Subject has 2 schemata in her mind about rectangle formula, and there were $2 \times p + l$ or $p + l \times 2$ and $p \times l$. She felt confuse about this. She can't assimilate her schema about the sense of the rectangle to her schemata about the formulas of the rectangle. One reason of subject's inability to assimilate her schemata was her incompleteness schemata. As a result, subject faced her cognitive conflict. She had been in conflict, and it was between her concept about the area and the circumference of the rectangle and the sense of the rectangle.

R : OK, what do you think about this one (pointing to her answer sheet as shown in Figure 6 below)

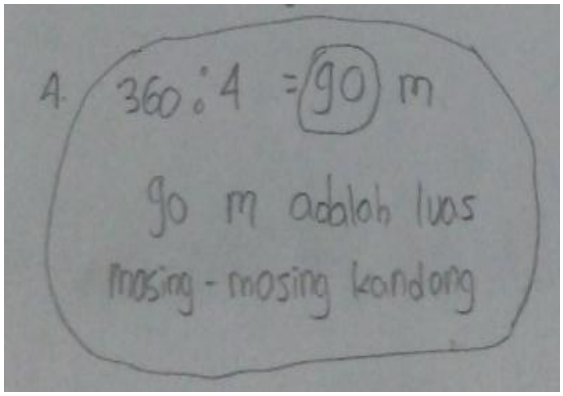

Figure 6: Subject's Answer Sheet

S : Oh, we know before that the area of the rectangle was $360m$. Because of the cage on the land was a triangle, so we can found four cages on the land. Then it was easily to find the area of each cage. Just divide the area of the rectangle to four then we can found that the area of each cage was $90m$. Hmmm...

S : Wait a moment mam... I think it was a wrong answer mam.

S : I know there was something queer to my understating of rectangle, but I don't know how should it be and what the correct answer is

R : OK, how long the wire will be used to make the cage, do you think?

S : hmm we know that a rectangle has three edges, and because the size of each cage was $90\ m$, so we can count the length of the wire that will be used to make the cage.

S : The length can be calculate by divide $90\ m$ to three, and we found the length of the wire was $30\ m$

S : But mam, is that true? It was strange mam.

Subject still in her conflict, she failed to make a better situation to construct her schemata about rectangle. Based on this situation, we made subject's conflict map as figured in Figure 7.

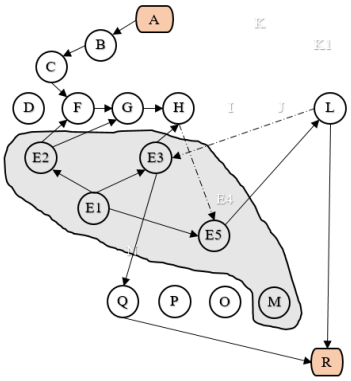

Figure 7: Student's Conflict Map

Lee, Kwon, Park, Kim, Kwon, Park (2003) stated that there was three stages in cognitive conflict model proses. They are preliminary stage, conflict stage, and resolution stage. In this research, we just investigate subject's conflict with out any intervention and with out any efforts to investigate her resolution stage.

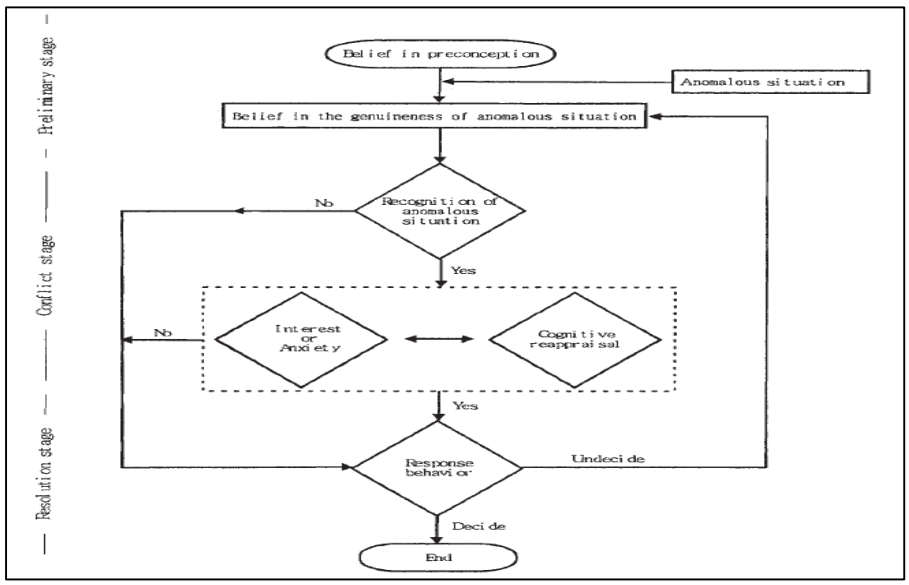

Figure 8: Cognitive Conflict Model Process (Lee, Kwon, Park, Kim, Kwon, Park, 2003)

Students' behaviour during the stages of the conflict can be described in Figure 9.

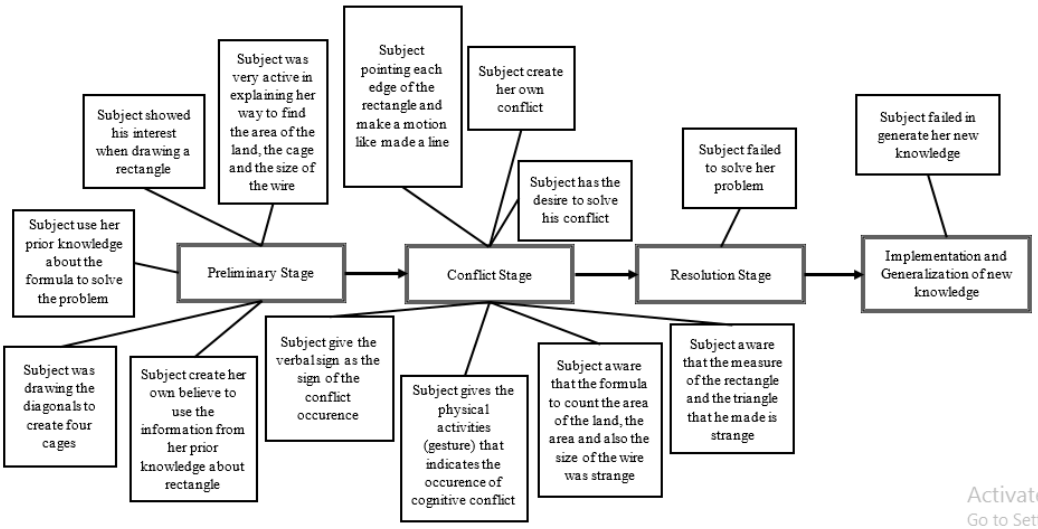

Figure 9: Subject's Diagram of Cognitive Conflict and The Activities in Each Conflict Stages

CONCLUSSION

Subject's schemata about the basic concept to solve the problem was incomplete. She can't use them while solving the given problem. Cognitive conflicts experienced by the subject is due to the contradiction between her incomplete concept. Cognitive conflicts experienced by the subject is the internal conflict that arising from the existence of the subject's inability to connect (mis-connection) and to rearrange her own concepts. There were concept smithereens fenomena that alleged as the trigger of subject's cognitive conflict. In this research, subject failed to resolve her conflict and the impact is she failed to generate her new knowledge. (Limon, 2001) (Dekkers, P. J. J. M., & Thijs G. D., 1998) (Leo, E. L. & Galloway, D., 1996)

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